



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number:

0 653 388 A1

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: **94117722.2**

(51) Int. Cl.⁶: **C03C 4/02, C03C 3/087**

(22) Date of filing: **10.11.94**

(30) Priority: **16.11.93 US 153733**

(43) Date of publication of application:
17.05.95 Bulletin 95/20

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB IT LI LU SE

(71) Applicant: **PPG INDUSTRIES, INC.**
One PPG Place
Pittsburgh
Pennsylvania 15272 (US)

(72) Inventor: **Krumwiede, John Franklin**
315 Blue Run Road
Cheswick, Pa. 15024 (US)
Inventor: **Longobardo, Anthony Vincent**
R.D. No.4,
222 Great Belt Road
Butler, Pa. 16001 (US)
Inventor: **Shelestak, Larry John**
1046 Ford Street,
P.O. Box 233
Bairdford, Pa. 15006 (US)

(74) Representative: **Sternagel, Hans-Günther, Dr.**
et al
Patentanwälte Dr. Michael Hann, Dr. H.-G.
Sternagel, Dr. H. Dörries,
Sander Aue 30
D-51465 Bergisch Gladbach (DE)

(54) **Gray glass composition.**

(57) The present invention provides a glass composition having a neutral gray color and a luminous (visible) transmittance within a range that allows the glass to be used as privacy glazing in a vehicle. The base glass is a soda-lime-silica composition and iron, cobalt, selenium and/or are added as colorants. In one particular embodiment of the invention, a neutral gray colored glass with a luminous transmittance (C.I.E. illuminant A) ranging from 20% to 50% at a thickness of 3.9 millimeters may be attained by using as colorants: 0.15 to 1.2 wt. % of the total glass Fe₂O₃ (total iron), no greater than 0.30 wt. % FeO, 60-180 PPM CoO, 0-30 PPM Se, and 0-550 PPM NiO.

BACKGROUND OF THE INVENTION

This invention involves a neutral gray colored glass that has a luminous transmittance that makes it highly desirable for use as privacy glazing in vehicle, e.g. in the rear portions of vans. In particular, the 5 glass of the present invention has a luminous transmittance range of 20 to 50%. The desired color and performance is attained by using iron, cobalt, selenium and/or nickel as colorants. In addition, the glass of the present invention generally exhibits lower infrared and total solar energy transmittance than typical green glasses used in automotive applications to reduce heat gain in the interior of the enclosure. The glass is also compatible with flat glass manufacturing methods.

10 Various heat-absorbing glass substrates are known in the art. The primary colorant in typical green tinted automotive glasses is iron, which is usually present in both the Fe_2O_3 and FeO forms. As is conventional, the total amount of iron present in a glass is expressed herein as Fe_2O_3 , regardless of the form actually present. Typical green tinted automotive glass has about 0.5 percent by weight total iron, with the ratio of FeO to total iron being about 0.25.

15 Some glasses, e.g. U.S. Reissue Patent No. 25,312 to Duncan et al., produce a gray color in the glass by including nickel oxide as a colorant. However, inclusion of nickel containing materials must be carefully controlled because the presence of nickel during the melting process sometimes leads to the formation of nickel sulfide stones in the glass. Additional potential problems faced when using nickel include haze formation on the glass surface due to reduction of the nickel in the tin bath and change in the glass color 20 when it is heat treated.

To avoid this problem, nickel-free colored glasses containing iron oxide, cobalt oxide, and selenium were developed as disclosed in U.S. Patent No. 3,296,004 to Duncan et al., U.S. Patent No. 3,723,142 to Kato et al. and British Patent Specification 1,331,492 to Bamford. In U.S. Patent No. 4,104,076 to Pons, instead of nickel, Cr_2O_3 or UO_2 are used in combination with iron oxide, cobalt oxide, and selenium to 25 produce gray glass. A more recent, nickel-free version of gray glass is disclosed in U.S. Patent No. 5,023,210 to Krumwiede et al. which uses iron oxide, cobalt oxide, selenium, and chromic oxide as colorants.

Many of the commercially available gray glasses are too dark to be used in the forward vision area of a 30 vehicle. In addition, the glasses may also be too dark to allow safety lighting mounted in the interior of the vehicle from being seen from the exterior of the vehicle. It would be desirable to have a neutral gray glass that provides a dark gray color for use in privacy areas of a vehicle while allowing adequate safety lighting illumination and have a consistent color and further that is compatible with commercial flat glass manufacturing techniques.

35 SUMMARY OF THE INVENTION

The present invention provides a glass composition having a neutral gray color and a luminous (visible) transmittance within a range that allows the glass to be used as privacy glazing in a vehicle. The glass of the present invention has a standard soda-lime-silica flat glass base composition. It has been found that a 40 neutral gray colored glass with a luminous transmittance (C.I.E. illuminant A) ranging from 20% to 50% at a thickness of 3.9 millimeters may be attained by using as colorants: 0.15 to 1.2 wt. % of the total glass Fe_2O_3 (total iron), no greater than 0.30 wt. % FeO , 60-180 PPM CoO , 0-30 PPM Se, and 0-550 PPM NiO . A preferred embodiment of such a glass composition includes 0.20 to 1.1 wt. % Fe_2O_3 , 0.05 to 0.29 wt. % FeO , 62 to 170 PPM CoO , 0 to 24 PPM Se and 0 to 500 PPM NiO .

45 The dominant wavelength of the glasses in the present invention may vary somewhat in accordance with particular color preferences. In the present invention, it is preferred that the glass be a neutral gray color characterized by dominant wavelengths in the range of 480 to 580 nanometers, preferably 485 to 540 nanometers, with an excitation purity of no higher than 8%, preferably no higher than 3%.

50 DETAILED DESCRIPTION

The base glass of the present invention, that is, the major constituents of the glass without colorants, is commercial soda-lime-silica glass characterized as follows:

	Weight %
SiO ₂	66-75
Na ₂ O	10-20
CaO	5-15
MgO	0-5
Al ₂ O ₃	0-5
K ₂ O	0-5
BaO	0-1

5

10

To this base glass the present invention adds colorants in the form of iron, cobalt, selenium and/or nickel. In one particular embodiment of the invention, the glass is essentially nickel-free; that is, no deliberate addition of nickel or nickel compounds is made, although the possibility of traces of nickel due to contamination may not always be avoided. The glass in the present invention is essentially free of other colorants. It should be appreciated that the glass compositions disclosed herein may include small amounts of other materials, for example melting and refining aids, tramp materials or impurities. Such materials may include, but are not limited to chromium, manganese, cerium, molybdenum, titanium, chlorine, zinc, zirconium, sulfur, fluorine, lithium and strontium. It should be further appreciated that some of these materials as well as others may be added to the glass to improve the solar performance of the glass as will be discussed later in more detail.

20

The selenium colorant contributes a pink color to the glass as well as a brown color when complexed with iron to form iron selenide (FeSe). Cobalt produces a blue color. Iron contributes yellow and blue in varying proportions depending upon the oxidation state. Nickel, if used, contributes a green-brown to yellow-brown color.

25

The glass of the present invention may be melted and refined in a continuous, large-scale, commercial melting operation and formed into flat glass sheets of varying thicknesses by the float method in which the molten glass is supported on a pool of molten metal, usually tin, as it assumes a ribbon shape and is cooled. It should be appreciated that as a result of forming the glass on molten tin, measurable amounts of tin oxide may migrate into surface portions of the glass on the side that was in contact with the tin. Typically, a piece of float glass has an SnO₂ concentration of at least 0.05 wt. % in the first few microns below the surface of the glass that was in contact with the tin.

30

The total amount of iron present in the glass is expressed herein in terms of Fe₂O₃ in accordance with standard analytical practice, but that does not imply that all of the iron is actually in the form of Fe₂O₃. Likewise, the amount of iron in the ferrous state is reported as FeO, even though it may not actually be present in the glass as FeO. The proportion of the total iron in the ferrous state is used as a measure of the redox state of the glass and is expressed as the ratio FeO/Fe₂O₃, which is the weight percent of iron in the ferrous state (expressed as FeO) divided by the weight percent of total iron (expressed as Fe₂O₃). Unless stated otherwise, the term Fe₂O₃ in this specification shall mean total iron expressed in terms of Fe₂O₃ and the term FeO shall mean iron in the ferrous state expressed in terms of FeO.

40

The glass compositions disclosed in the present invention may be made using any of several types of melting arrangements, such as but not limited to, a conventional, overhead fired continuous melting operation as is well known in the art or a multi-stage melting operation, of the type that is discussed later in more detail. However, for glass compositions having a redox of less than 0.30, the former operation is preferred and for glass compositions having a redox of 0.30 or greater, the latter operation is preferred.

45

Conventional, overhead fired continuous melting operations are characterized by depositing batch material onto a pool of molten glass maintained within a tank type melting furnace and applying thermal energy until the materials are melted into the pool of molten glass. The melting tanks conventionally contain a large volume of molten glass so as to provide sufficient residence time for currents in the molten glass to affect some degree of homogenization and fining before the glass is discharged into a forming operation.

50

The multi-stage glass melting and refining operation disclosed in U.S. Patent Nos. 4,381,934 and 4,792,536 to Kunkle et al., 4,792,536 to Pecoraro et al. and 4,886,539 to Cerutti et al. is characterized by separate stages whereby more flexibility in controlling redox conditions is provided. The overall melting process disclosed in these patents consists of three stages: a liquefaction stage, a dissolving stage, and a vacuum refining stage. In the liquefaction stage, batch materials, preferably in a pulverulent state, are fed into a rotating, drum-shaped liquefying vessel. As batch material is exposed to the heat within the vessel, liquefied material flows down a sloped batch material lining to a central drain opening at the bottom of the vessel. A stream of liquefied material falls freely from the liquefaction vessel into a dissolving vessel for the dissolving stage. The dissolving vessel completes the dissolution of unmelted particles in the liquefied

material coming from the liquefaction stage by providing residence time at a location isolated from the downstream refining stage. The dissolving vessel may be in the form of a horizontally elongated refractory basin with the inlet and outlet at opposite ends thereof so as to assure adequate residence time. The refining stage preferably consists of a vertically upright vessel that may be generally cylindrical in configuration having an interior ceramic refractory lining shrouded in a gas-tight, water-cooled casing. As the molten material enters the vessel from the dissolving vessel, it encounters a reduced pressure within the refining vessel. Gases included in the melt expand in volume, creating a foam. As foam collapses, it is incorporated into the liquid body held in the refining vessel. Refined molten material is drained from the bottom of the refining vessel into a receiving chamber and delivered to a float forming chamber.

10 A stirring arrangement may be employed in the multi-stage process to homogenize the glass after it has been refined in order to produce glass of the highest optical quality. If desired, a stirring arrangement may be integrated with a float forming chamber, whereby the glass in the stirring chamber rests on a layer of molten metal. The molten metal may be continuous with the molten metal constituting the support in the forming chamber, and is usually comprised essentially of tin.

15 The multi-stage operation discussed above generally operates at a redox level of 0.30 or higher; however redox levels below 0.30 may be achieved by increasing the amount of oxidizing constituents in the glass batch. For example, manganese oxide may be added to lower the redox level. Redox may also be controlled by adjusting the gas/O₂ ration of the burners.

20 The transmittance data provided throughout this disclosure is based on a glass thickness of 3.9 millimeters (0.154 inch). Luminous transmittance (LTA) is measured using C.I.E. 1931 standard illuminant "A" over the wavelength range 380 to 770 nanometers at 10 nanometer intervals. Total solar ultraviolet transmittance (TSUV) is measured over the wavelength range 300 to 390 nanometers at 10 nanometer intervals. Total solar infrared transmittance (TSIR) is measured over the wavelength range 800 to 2100 nanometers at 50 nanometer intervals. Total solar energy transmittance (TSET) represents a computed value based on measured transmittances from 300 to 2100 nanometers at 50 nanometer intervals. All solar transmittance data is calculated using Parry Moon air mass 2.0 solar data. Glass color in terms of dominant wavelength and excitation purity are measured using C.I.E. 1931 standard illuminant "C" with a 2° observer.

25 To determine this transmittance data, the transmittance values are integrated over the wavelength range [a,b]. This range is divided into n equal subintervals of length h by points {X₀, X₁, ..., X_n} where X_i = a + (i x h). In the present disclosure, the Rectangular Rule is used to compute the transmittance data. An interpolating function is used to approximate the integrand f in each subinterval. The sum of integrals of this function provides an approximation of the integral:

35

$$I = \int_b^a f(X)dX$$

40 In the case of the Rectangular Rule, a constant value f(X_i) is used as an approximation of f(X) on [X_{i-1}, X_i]. This yields a step-function approximation of f(X) on [a,b], and the numerical integration formula:

45

$$I = \sum_{i=1}^n f(X_i) \times h$$

50 Tables 1, 2 and 3 illustrate examples of glass compositions at a 3.9 mm (0.154 in.) reference thickness which embody the principles of the present invention. Only the colorant portions of the examples are listed in the table below, with Fe₂O₃ being total iron, including that present as FeO.

The information provided in Tables 1 and 2 is based on a computer model that generates theoretical spectral properties based on the glass compositions. The compositions in Table 1 exclude nickel oxide as a colorant while the compositions in Table 2 include nickel oxide as a colorant. The information provided in Examples 31, 32, 33 and 34 in Table 3 is based on experimental laboratory melts. The remaining information in Table 3 is based on actual glass produced using the multi-stage melting process discussed earlier. However, under certain conditions, it may be preferred that the glasses disclosed in the present invention be made using a conventional, overhead fired continuous melting process as discussed earlier.

It should be noted that the modeled compositions in Table 1 included from 6 to 13 PPM of Cr₂O₃ and 1 PPM NiO, both of which are considered to be tramp and/or residual material levels, to better reflect the expected spectral properties of the glass. The compositions in Table 2 included similar Cr₂O₃ levels. In addition, the analysis of the experimental melts in Table 3 showed less than 3 PPM NiO and from 6 to 13 PPM Cr₂O₃. The analysis of the actual production glass disclosed in Table 3 showed less than 3 PPM NiO and between 5 to 8 PPM Cr₂O₃.

The representative base glass composition for the examples is as follows:

		Examples 1-34	Examples 35-39
10	SiO ₂	72.5% by weight	72.0% by weight
15	Na ₂ O	13.6	13.5
	CaO	8.8	8.8
	MgO	3.8	3.8
	Al ₂ O ₃	0.12	0.59

It should be appreciated that this composition may vary especially as a result of the actual amount of colorant present in the glass composition.

20

25

30

35

40

45

50

55

50 45 40 35 30 25 20 15 10 5

TABLE I

	<u>Ex. 1</u>	<u>Ex. 2</u>	<u>Ex. 3</u>	<u>Ex. 4</u>	<u>Ex. 5</u>	<u>Ex. 6</u>	<u>Ex. 7</u>	<u>Ex. 8</u>	<u>Ex. 9</u>	<u>Ex. 10</u>	<u>Ex. 11</u>	<u>Ex. 12</u>	<u>Ex. 13</u>	<u>Ex. 14</u>
Fe ₂ O ₃ wt. %	0.935	0.820	1.100	0.820	0.820	0.820	0.710	1.000	0.710	0.600	0.710	0.710	0.450	0.600
FeO wt. %	0.261	0.209	0.281	0.209	0.209	0.209	0.181	0.255	0.181	0.153	0.181	0.181	0.115	0.153
Redox	0.279	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255
CoO PPM	148	150	124	124	100	125	98	98	103	98	75	98	65	
Se PPM	23	20	24	16	20	14	14	17	15	11	14	14	9	
LTA	27.95	34.35	34.43	35.58	39.28	40.42	41.48	41.6	43.63	45.45	47.01	48.81	48.88	52.43
TSIR	18.09	24.79	16.35	24.76	24.89	24.85	29.46	19.09	29.44	34.90	29.56	29.53	44.11	34.99
TSUV	13.21	17.06	12.17	15.98	18.30	17.14	21.74	15.22	20.72	24.69	22.93	21.85	30.74	26.05
TSET	23.58	30.30	24.95	30.32	32.38	32.32	36.16	29.62	36.51	40.63	38.41	38.60	47.34	43.48
DW nm	500.3	489.5	551	572.4	495.	569.1	487.5	532.5	562.5	498.1	493.2	563	483.1	524.4
Pe %	0.97	2.66	3.67	4.84	2.39	5.41	4.17	2.51	2.7	0.90	3.02	3.88	1.27	1.13

6

TABLE 2

		<u>Ex. 15</u>	<u>Ex. 16</u>	<u>Ex. 17</u>	<u>Ex. 18</u>	<u>Ex. 19</u>	<u>Ex. 20</u>	<u>Ex. 21</u>	<u>Ex. 22</u>
5	Fe ₂ O ₃ wt.%	0.935	0.935	0.935	0.820	0.820	0.820	0.600	0.400
10	FeO wt. %	0.238	0.238	0.238	0.209	0.209	0.209	0.153	0.102
	Redox	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255
15	CoO PPM	170	160	150	124	124	124	110	102
	Se PPM	19	19	19	18	20	20	10	6
20	NiO PPM	200	150	100	200	150	50	200	400
	LTA	24.48	26.21	28.06	33.86	34.07	36.25	41.74	42.21
	TSIR	20.36	20.25	20.55	24.44	24.51	24.72	34.40	46.29
25	TSUV	13.51	13.56	13.62	17.49	16.96	17.05	26.55	36.94
	TSET	23.56	24.30	25.08	29.55	29.62	30.73	38.95	45.87
	DW nm	502.6	505.4	509.2	566.3	568.7	562.6	515.8	558.8
30	Pe %	1.62	1.40	1.22	6.16	6.2	3.27	1.29	3.55

TABLE 2 (cont'd.)

		<u>Ex. 23</u>	<u>Ex. 24</u>	<u>Ex. 25</u>	<u>Ex. 26</u>	<u>Ex. 27</u>	<u>Ex. 28</u>	<u>Ex. 29</u>	<u>Ex. 30</u>
35	Fe ₂ O ₃ wt.%	0.710	0.710	0.600	0.500	0.200	0.500	0.500	0.500
	FeO wt. %	0.181	0.181	0.153	0.128	0.051	0.128	0.128	0.128
	Redox	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255
40	CoO PPM	98	98	102	80	102	100	80	67
	Se PPM	14	14	12	4	0	8	2	7
45	NiO PPM	100	50	100	400	500	200	400	100
	LTA	42.58	43.92	44.50	45.10	45.34	45.52	46.23	51.89

	TSIR	29.25	29.38	36.67	39.69	63.20	40.24	39.74	40.58
5	TSUV	21.68	21.74	25.84	33.32	55.13	31.41	34.46	30.90
TSET	36.03	36.72	40.17	43.21	56.99	43.91	43.86	46.55	
DW nm	558.9	546.2	513.6	561.3	513.2	505.5	553.4	528.1	
10	Pe %	3.37	1.91	.97	6.00	1.24	1.34	4.54	1.21

15

TABLE 3

	Ex. 31	Ex. 32	Ex. 33	Ex. 34	Ex. 35	Ex. 36	Ex. 37	Ex. 38	Ex. 39	
20	Fe ₂ O ₃ wt. %	0.935	0.930	0.818	0.820	0.822	0.811	0.772	0.720	0.657
	FeO wt. %	0.261	0.257	0.245	0.257	0.216	0.212	0.198	0.185	0.160
	Redox	0.279	0.276	0.300	0.313	0.263	0.261	0.257	0.257	0.244
25	CoO PPM	128	120	126	124	104	101	90	75	62
	Se PPM	19	19	18	21	16	17	15	12	11
	LTA	31.20	31.95	32.08	35.83	36.15	36.57	41.05	46.30	51.85
30	TSIR	18.07	18.40	19.25	18.34	25.12	26.01	28.34	29.32	32.62
	TSUV	17.35	16.59	22.81	24.15	21.55	21.52	24.08	27.97	31.75
	TSET	25.17	25.52	26.75	27.46	31.70	32.26	35.42	38.27	42.43
	DW nm	496.3	515.6	488.8	497.6	486.4	489.5	500.8	496.9	510.8
	Pe	1.72	1.05	2.79	1.59	2.62	1.41	0.62	1.05	0.65

Referring to Tables 1, 2 and 3, the present invention provides a neutral gray colored glass using a standard soda-lime-silica glass base composition and iron, cobalt, selenium and/or nickel as colorants. Not all of the examples are the same gray color as indicated by the dominant wavelengths (DW) and excitation purities (Pe). In the present invention, it is preferred that the glass be a neutral gray color characterized by dominant wavelengths in the range of 480 to 580 nanometers, preferably 485 to 540 nanometers, with an excitation purity of no higher than 8%, preferably no higher than 3%.

In the present invention, the colorants used to produce a neutral gray colored glass with an LTA ranging from 20% to 50% at a thickness of 3.9 millimeters includes 0.15 to 1.2 wt. % Fe₂O₃ (total iron), up to 0.30 wt. % FeO, 60-180 PPM CoO, 0-30 PPM Se and 0-550 PPM NiO, and preferably 0.20 to 1.1 wt. % Fe₂O₃, 0.05 to 0.29 wt. % FeO, 62 to 170 PPM CoO, 0 to 24 PPM Se and 0 to 500 PPM NiO.

The redox ratio for the glass of the present invention is maintained between about 0.20 to 0.30, and preferably between 0.24 to 0.28 which is the typical operating range for a conventional overhead fired melting operation. Higher redox levels may be attained by processes disclosed herein, but the use of higher redox ratios is preferably avoided to prevent excessive volatilization of selenium during melting.

45 Glass made by the float process typically ranges from a sheet thickness of about 1 millimeters to 10 millimeters. For the vehicle glazing applications, it is preferred that the glass sheets have a thickness within the thickness range of 1.8 to 6 millimeters.

If desired, ultraviolet radiation absorbing materials may be added to the glass compositions of the present invention to improve its solar performance. Although not limiting in the present invention, a total of 50 up to 2.0 wt. % of oxides of cerium, vanadium, titanium and molybdenum and combinations thereof may be used as UV absorbers to reduce the TSUV of the glass. In a preferred embodiment of the invention, TiO₂ is the preferred UV absorber and may be added in an amount ranging from 0.1 to 1.0 wt. % of the glass composition, and more preferably 0.2 to 0.5 wt. %.

55 Other variations as are known to those of skill in the art may be resorted to without departing from the scope of the invention as defined by the claims that follow.

Claims

1. A neutral gray colored glass composition having a base glass portion comprising:

5	<table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 20%;">SiO₂</td><td style="width: 80%;">66 - 75 percent by weight</td></tr> <tr><td>Na₂O</td><td>10 - 20</td></tr> <tr><td>CaO</td><td>5 - 15</td></tr> <tr><td>MgO</td><td>0 - 5</td></tr> <tr><td>Al₂O₃</td><td>0 - 5</td></tr> <tr><td>K₂O</td><td>0 - 5</td></tr> </table>	SiO ₂	66 - 75 percent by weight	Na ₂ O	10 - 20	CaO	5 - 15	MgO	0 - 5	Al ₂ O ₃	0 - 5	K ₂ O	0 - 5
SiO ₂	66 - 75 percent by weight												
Na ₂ O	10 - 20												
CaO	5 - 15												
MgO	0 - 5												
Al ₂ O ₃	0 - 5												
K ₂ O	0 - 5												
10													

and a colorant portion consisting essentially of:

15	<table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 20%;">Fe₂O₃ (total iron)</td><td style="width: 80%;">0.15 to 1.2 percent by weight</td></tr> <tr><td>FeO</td><td>up to 0.30</td></tr> <tr><td>CoO</td><td>60 - 180 PPM</td></tr> <tr><td>Se</td><td>0 - 30 PPM</td></tr> <tr><td>NiO</td><td>0 - 550 PPM</td></tr> </table>	Fe ₂ O ₃ (total iron)	0.15 to 1.2 percent by weight	FeO	up to 0.30	CoO	60 - 180 PPM	Se	0 - 30 PPM	NiO	0 - 550 PPM
Fe ₂ O ₃ (total iron)	0.15 to 1.2 percent by weight										
FeO	up to 0.30										
CoO	60 - 180 PPM										
Se	0 - 30 PPM										
NiO	0 - 550 PPM										
20											

the glass having a luminous transmittance of 20 to 50 percent at a thickness of 3.9 millimeters.

2. The composition as in claim 1 wherein the Fe₂O₃ concentration is from 0.20 to 1.1 weight percent, the FeO concentration is from 0.05 to 0.29 weight percent, the CoO concentration is from 62 to 170 PPM, and the Se concentration is from 0 to 24 PPM.

3. The composition as in claim 1 wherein the Fe₂O₃ concentration is from 0.40 to 1.2 weight percent, the FeO concentration is from 0.10 to 0.29 weight percent, the CoO concentration is from 60 to 160 PPM, the Se concentration is from 5 to 30 PPM and further wherein said composition is essentially nickel-free.

4. The composition as in claim 3 wherein the Fe₂O₃ concentration is from 0.45 to 1.1 weight percent, the FeO concentration is from 0.11 to 0.285 weight percent, the CoO concentration is from 62 to 150 PPM and the Se concentration is from 9 to 24 PPM.

5. The composition as in claim 1 wherein the Fe₂O₃ concentration is from 0.15 to 1.0 weight percent, the FeO concentration is from 0.04 to 0.25 weight percent, the CoO concentration is from 60 to 180 PPM, the Se concentration is from 0 to 25 PPM and the NiO concentration is at least 25 PPM.

6. The composition as in claim 5 wherein the Fe₂O₃ concentration is from 0.20 to 0.94 weight percent, the FeO concentration is from 0.05 to 0.24 weight percent, the CoO concentration is from 67 to 170 PPM, the Se concentration is from 0 to 20 PPM and the NiO concentration is at least 50 PPM.

7. The composition of claim 1 wherein the color of the glass is characterized by dominant wavelengths in the range of 480 to 580 nanometers and an excitation purity of no higher than 8% at a thickness of 3.9 millimeters.

8. The composition of claim 7 wherein the color of the glass is characterized by dominant wavelengths in the range of 485 to 540 nanometers and an excitation purity of no higher than 3%.

9. The composition as in claim 1 further including additional ultraviolet absorbing material.

10. The composition as in claim 9 wherein said ultraviolet absorbing material is an oxide of a material selected from a group consisting essentially of cerium, vanadium, titanium and molybdenum and combination thereof in an amount up to 2.0 wt. % of the glass composition.

11. The composition as in claim 10 wherein said TiO₂ is in an amount from 0.1 to 1.0 wt. %.

12. The composition as in claim 11 wherein said TiO₂ is in an amount from 0.2 to 0.5 wt. %.
13. A glass sheet made from the composition as recited in claim 1.
- 5 14. The glass sheet as in claim 13 wherein the sheet has a thickness between 3 to 6 mm.
15. The glass sheet as in claim 13 wherein the color of the glass is characterized by dominant wavelengths in the range of 480 to 580 nanometers and an excitation purity of no higher than 8% at a thickness of 3.9 millimeters.
- 10 16. The glass sheet as in claim 15 wherein the color of the glass is characterized by dominant wavelengths in the range of 485 to 540 nanometers and an excitation purity of no higher than 3%.

15

20

25

30

35

40

45

50

55



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 11 7722

DOCUMENTS CONSIDERED TO BE RELEVANT					
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)		
X	EP-A-0 536 049 (SAINT-GOBAIN VITRAGE) * page 2, line 24 - page 3, line 18 * * claims 1,2,4,5,9 * ---	1,3,7, 13-15	C03C4/02 C03C3/087		
A	EP-A-0 349 909 (PPG INDUSTRIES) * claims 1,2,6; example 7 * ---	1,3,13			
A	EP-A-0 482 535 (PPG INDUSTRIES) * claims 1,7 * ---	1,3,13			
A	GB-A-2 071 082 (BFG GLASSGROUP) * examples * ---	1,13			
A	EP-A-0 452 207 (SAINT-GOBAIN VITRAGE) * the whole document * ---	1,3,13			
D,A	US-A-4 104 076 (A. PONS) * examples 5-7 * ---	1			
D,A	US-A-5 023 210 (KRUMWIEDE ET AL.) * claim 1 * -----	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) C03C		
The present search report has been drawn up for all claims					
Place of search	Date of completion of the search	Examiner			
THE HAGUE	21 February 1995	Puettz, C			
CATEGORY OF CITED DOCUMENTS					
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document					
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document					